HYDROLOGY SPECIALIST REPORT
Snowmass Snowmaking
Environmental Assessment

Prepared for:

United States Forest Service
White River National Forest
Aspen-Sopris Ranger District

Prepared by:

Resource Engineering, Inc.
909 Colorado Avenue
Glenwood Springs CO 81601
(970) 945-6777

December 10, 2018

Job No. 563-6.14

RESOURCE ENGINEERING INC.

TABLE OF CONTENTS

PAGE

1.0 INTRODUCTION 1
2.0 FOREST PLAN DIRECTION 1
2.1 MANAGEMENT AREA 8.25 – FOREST PLAN STANDARD 1
2.2 APPLICABLE WCPH MANAGEMENT MEASURES 2
2.3 RELEVANT WCPH DEFINITIONS 2
3.0 AFFECTED ENVIRONMENT 3
3.1 PROJECT AREA DESCRIPTION 3
3.2 WATERSHED CONDITION 4
4.0 DIRECT AND INDIRECT ENVIRONMENTAL CONSEQUENCES 13
4.1 ALTERNATIVE 1 – NO ACTION 13
4.2 ALTERNATIVE 2 – PROPOSED ACTION 13
5.0 CUMULATIVE EFFECTS 19
5.1 SCOPE OF THE ANALYSIS 19
5.2 CUMULATIVE EFFECTS ANALYSIS 20
6.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES 21
6.1 ALTERNATIVE 1 22
6.2 ALTERNATIVE 2 22
REFERENCES

LIST OF TABLES

Table 1. Soils Guideline 1 – Ground Cover Requirements 1
Table 2. Snowmass Creek Multi-Stage Wintertime Instream Flow Requirements 5
Table 3. Study Watersheds – Comparison of Baseline and Existing Conditions 8
Table 4. WRENSS Model Output for Baseline and Existing Conditions 9
Table 5. Connected Roads within the Study Watersheds – Existing Conditions 11
Table 6. Connected Disturbed Areas within the Study Watersheds – Existing Conditions 11
Table 7. Impacts to WIZ - Baseline vs Existing Conditions 12
Table 8. Soil Characteristics in Project Area 12
Table 9. Estimated Changes to Annual Yield – Alternative 2 15
Table 10. Estimated Changes to Peak Runoff – Alternative 2 15
Table 11. Comparison of Existing vs Proposed Snowmaking Coverage 16
Table 12. Summary of Watershed Condition Indicators 20

LIST OF FIGURES

Figure 1. WRENSS Model Output: Brush Creek Tributary 1 Hydrographs 9
Figure 2. WRENSS Model Output: Brush Creek Tributary 2 Hydrographs 10

LIST OF ATTACHMENTS

ATTACHMENT A – Report Maps

Figure A-1. Study Watersheds Map

Figure A-2. CDAs and Trail Erosion Map

Figure A-3. Cumulative Effects Watersheds Map

ATTACHMENT B – Photographs

1.0 INTRODUCTION

The U.S. Forest Service (USFS), White River National Forest (WRNF), has initiated an Environmental Assessment (EA) for the Snowmaking and Elk Camp Meadows Projects proposed for the Snowmass Ski Area. Resource Engineering, Inc. (RESOURCE) has been retained to complete the watershed and soils analyses required for the EA. A Study Plan prepared by SE Group for the WRNF outlines the issues and indicators that need to be analyzed for completion of the EA.[1] This report describes the existing watershed and soils condition of the project area; presents the analysis of potential effects to these resources; and outlines recommendations to avoid or minimize such effects.

2.0 FOREST PLAN DIRECTION

Pursuant to the 2002 Forest Plan, as amended, stream health management measures and design criteria are provided in the Region 2 Watershed Conservation Practices Handbook (WCPH) to ensure applicable Federal and State laws are met on National Forest System (NFS) lands in Region 2.[2] The Forest Plan and the WCPH direct how snowmaking and land treatments are to be managed in the WRNF.

2.1 MANAGEMENT AREA 8.25 – FOREST PLAN STANDARD

Standard 3. Snow management, including snowmaking and snow-farming, will be conducted in a manner that prevents slope failures and gully erosion, as well as bank erosion and sediment damage in receiving channels.

Soils Standard 1. Effective ground cover (mulch) upon completion of ground disturbing activities will meet minimum levels of pre-treatment habitat type (Aspen – 95 percent, Lodgepole Pine – 90 percent, Spruce-Fir – 95 percent).

Soils Guideline 1. Ground cover as a combination of revegetation and mulch applications, should meet the requirements in **Table 1**, one and two years following completion of ground disturbing activities.

Table 1

Soils Guideline 1 – Ground Cover Requirements

Erosion Hazard Class	Year 1 Minimum Effective Ground Cover (%)	Year 2 Minimum Effective Ground Cover (%)
Low	20 to 30	30 to 40
Moderate	30 to 45	40 to 60
High	45 to 60	60 to 75
Very High/Severe	60 to 90	75 to 90

[1] SE Group, 2018.
[2] USDA Forest Service, 2002; USDA Forest Service, 2005.

2.2 APPLICABLE WCPH MANAGEMENT MEASURES

The WCPH contains several Management Measures (MM) which are environmental goals to protect aquatic and riparian systems. MM of relevance regarding watershed resources are outlined below:

- MM-1. Manage land treatments to conserve site moisture and to protect long-term stream health from damage by increased runoff.
- MM-2. Manage land treatments to maintain enough organic ground cover in each activity area to prevent harmful increased runoff.
- MM-3. In the water influence zone (WIZ) next to perennial and intermittent streams, lakes, and wetlands, allow only those actions that maintain or improve long-term stream health and riparian ecosystem condition.
- MM-5. Conduct actions so that stream pattern, geometry, and habitats maintain or improve long-term stream health.
- MM-16. Apply runoff controls to disconnect new pollutant sources from surface and groundwater.

2.3 RELEVANT WCPH DEFINITIONS

Additionally, the WCPH provides definitions for some terms that are important to conveying information in this report:

Concentrated-Use Site: Areas designed and managed for high density of people or livestock, such as developed recreation sites and livestock watering areas.

Connected Disturbed Areas: (CDAs) High runoff areas like roads and other disturbed sites that have a continuous surface flow path into a stream or lake. Hydrologic connection exists where overland flow, sediment or pollutants have a direct route to the channel network. CDAs include roads, ditches, compacted soils, bare soils, and areas of high burn severity that are directly connected to the channel system. Ground disturbing activities located within the water influence zone should be considered connected unless site-specific actions are taken to disconnect them from streams.

Ephemeral Stream: A stream that flows only in direct response to precipitation in the immediate locality (watershed or catchment basin), and whose channel is at all times above the zone of saturation.

Hydrologic Function: The ability of a watershed to infiltrate precipitation and naturally regulate runoff so streams are in dynamic equilibrium with their channels and floodplains.

Intermittent Stream: A stream or reach of stream channel that flows, in its natural conditions, only during certain times of the year or in several years. It is characterized by interspersed, permanent surface water areas containing aquatic flora and fauna adapted to the relatively harsh environmental conditions found in these types of environments.

Gully: An erosion channel greater than 1 foot deep.

Perennial Stream: A stream or reach of a channel that flows continuously or nearly so throughout the

year and whose upper surface is generally lower than the top of the zone of saturation in the areas adjacent to the stream.

Rill: An erosion channel less than 1 foot deep.

Stream Health: The condition of a stream versus reference conditions for the stream type and geology, using metrics such as channel geometry, large woody debris, substrate, bank stability, flow regime, water chemistry, and aquatic biota.

Stream Health Class: A category of stream health. Three classes are recognized in the Rocky Mountain Region: robust, at-risk and diminished. These classes are recommended to be used for assessing long-term stream health and impacts from management activities.

Stream Order: A method of numbering streams as part of a drainage basin network. The smallest unbranched mapped tributary is called first order, the stream receiving the tributary is called second order and so on.

Swale: A landform feature lower in elevation than adjacent hillslopes, usually present in headwater areas of limited areal extent, generally without display of a defined watercourse or channel that may or may not flow water in response to snowmelt or rainfall. Swales exhibit little evidence of surface runoff and may be underlain by porous soils and bedrock that readily accepts infiltrating water.

Water Influence Zone: The land next to water bodies where vegetation plays a major role in sustaining long-term integrity of aquatic systems. It includes the geomorphic floodplain (valley bottom), riparian ecosystem, and inner gorge. Its minimum horizontal width (from top of each bank) is 100 feet or the mean height of mature dominant late-seral vegetation, whichever is most.

3.0 AFFECTED ENVIRONMENT

3.1 PROJECT AREA DESCRIPTION

The scope of the analysis for the proposed Elk Camp Meadows and Snowmaking projects focuses on watershed and soil resources located on the Snowmass Ski Area (Snowmass) within NFS lands. Snowmass is situated at elevations ranging from 8,200 to 12,300 feet, receiving a significant portion of its annual precipitation as snow during the winter months. Annual precipitation at Snowmass averages 28 inches, with approximately 19 inches (or 68 percent of the annual precipitation) occurring between November and April. Monthly mean temperatures range between 17 and 26 degrees Fahrenheit and between 48 and 56 degrees Fahrenheit during the winter and summer months, respectively.[3] More specifically, the proposed snowmaking would be located on areas drained by two un-named tributaries to Brush Creek, tributary to the Roaring Fork River.

[3] PRISM Climate Group, 2018.

In addition, two relatively small facilities (a pole shed and an operations kiosk, about 600 square feet in size each) are proposed to be constructed in the Elk Camp Meadows area, within the East Fork of Brush Creek watershed. Both proposed structures would be constructed in previously cleared areas and would require minimal grading. The potential effects on the watershed and soils resources associated with construction of these facilities would be negligible and are not analyzed in this report.

The paragraphs below provide a summary description of the study watersheds. **Figure A-1** (attached) is a vicinity map of the study watersheds.

- **Brush Creek Tributary 1**, a first-order watershed and extending for 393 acres is the smallest study watershed. A small perennial stream channel was identified at the lower elevations of this watershed, below approximately 9,200 feet. In addition, an intermittent/ephemeral channel was observed near the Gwyn's High Alpine Restaurant, around 10,500 feet of elevation. This small stream collects surface drainage from the Showcase and lower section of Reidar's ski trails; it then flows into a forested area just down-slope from Gwyn's and dissipates/infiltrates into the ground.
- **Brush Creek Tributary 2**, also a first-order watershed its drainage area contains 649 acres. A small perennial/intermittent channels exists at the lower elevations of the watershed, approximately below 9,200 feet of elevation. Similar to Tributary 1, above this elevation the stream is an ephemeral channel.

3.2 WATERSHED CONDITION

3.2.1 Water Quality

Snowmass Creek Instream Flows

Instream flows are non-consumptive, in-channel water rights owned by the Colorado Water Conservation Board (CWCB) and administered within the State of Colorado water right priority system with the purpose of preserving or improving the natural environment to a reasonable degree. Instream flows for Snowmass Creek were decreed in Water Court Case No. W-2943 and apply to various reaches of the Creek, from the outlet of Snowmass Lake to its confluence with the Roaring Fork River. The instream flow reach from where snowmaking water is diverted spans from the confluence of Snowmass Creek with West Snowmass Creek down to its confluence with Capitol Creek. In summary, instream flows for the period October 16 through March 31 (snowmaking operations are typically conducted during November and December) are determined each year based upon a flow trigger defined as the average daily streamflow observed during the October 11 to October 16 period, and values shown in **Table 2**. For example, in 2018 the average streamflow in this reach of Snowmass Creek from October 11 to October 15 was 26 cfs (corresponding to a 1 in 4 to 1 in 10 years event, see **Table 2**), therefore during the snowmaking season the instream flows this year will be as follows:

- 10 cfs for the 11/1-11/14 period;

- 9 cfs during 11/15-12/21;
- 8.5 cfs from 12/22-12/28; and
- 8 cfs for 12/29-12/31.

Please note that this multi-stage wintertime instream flow requirements set forth in Case No. W-2943 are consistent with those included in the US Army Corps of Engineers' letter to the SWSD dated February 3, 1995.

Table 2
Snowmass Creek Multi-Stage Wintertime Instream Flow Requirements

			Multi-Stage Winter Instream Flow	
Instream Flow Trigger Average Daily Flow from 10/11 to 10/15	**Percentile Water Year**	**Predicted Recurrence Interval**	**Time Period**	**Minimum Instream Flow**
≥ 29.0 cfs	50th Percentile or greater	1 in 2 years	10/16 - 11/30	12 cfs
			12/1 - 3/30	10 cfs
27.0 cfs ≤ Avg Flow < 29.0 cfs	25th Percentile to 50th Percentile	1 in 4 years to 1 in 2 years	10/16 - 10/31	12 cfs
			11/1 - 12/14	10 cfs
			12/15 - 12/31	9 cfs
			1/1 - 3/31	10 cfs
19.0 cfs ≤ Avg Flow < 27.0 cfs	10th Percentile to 25th Percentile	1 in 10 years to 1 in 4 years	10/16 - 10/31	12 cfs
			11/1 - 11/14	10 cfs
			11/15 - 12/21	9 cfs
			12/22 - 12/28	8.5 cfs
			12/29 - 12/31	8 cfs
			1/1 - 3/31	9 cfs
< 19.0 cfs	Less than 10th Percentile	1 in 10 years or greater	10/16 - 10/21	9 cfs
			10/22 - 10/31	8 cfs
			11/1 - 12/31	7 cfs
			1/1 - 3/31	8 cfs

Source: Water Court Case No. W-2943

Snowmaking System

Snowmass obtains its snowmaking water supply from the 215-acre foot Ziegler Reservoir, owned and operated by the Snowmass Water and Sanitation District (SWSD). Ziegler Reservoir is an integral part of the SWSD's water supply system which includes numerous water rights. Among these, the Snowmass Creek Pipeline is decreed for an amount of 6 cfs for snowmaking uses (Water Court Case Nos. 92CW0307, 02CW0024, and 09CW0038).

The Snowmass snowmaking system includes three on-mountain storage ponds: Sheer Bliss, Rayburn's, and Burlingame. These ponds start the snowmaking season at full capacity as a result of seasonal run-off and/or available streamflows. As a key part of the overall snowmaking infrastructure, these ponds are

drained and filled several times during the course of the snowmaking season as necessary with system water from Ziegler Reservoir. Typically, refilling of the on-mountain storage ponds takes place during periods of warm temperatures when pumped water cannot be processed into snow.

Based on snowmaking records provided by ASC, Snowmass uses, on average, 46 AF of water per season for construction and maintenance of their terrain parks features, such as jumps and half-pipe, and 197 AF to make man-made snow on approximately 260 acres of ski trails. Therefore, production of artificial snow on the Snowmass ski trails requires approximately 0.76 AF of water per acre of treated ski trail (197 / 260 = 0.76). A portion of the volume of water pumped during snowmaking operations is subject to losses due to evaporation, sublimation, and evapotranspiration (watershed losses). Mostly, these losses depend upon air temperatures during the snowmaking process, the volume of water pumped, and the type of year (dry, average, or wet). Calculations completed with the WRENSS model for the study watersheds show that snowmaking water losses (depletions) during average year conditions total approximately 26 percent.

Prior to the 2011 improvements to Ziegler Reservoir, snowmaking water was drawn directly from Snowmass Creek at varying rates, up to 6 cfs as needed by snowmaking operations and as allowed by Snowmass Creek instream flows. While Ziegler Reservoir still requires replenishment from Snowmass Creek during the snowmaking season, most of the snowmaking water is now drawn from Snowmass Creek into storage during periods of maximum streamflow availability, therefore reducing demand upon the stream system during low-flow time periods. Because water needed for snowmaking operations is drawn from Ziegler Reservoir and/or from one or more of the on-mountain storage ponds (and not directly from the Snowmass Creek) impacts to the CWCB decreed instream flow water right on Snowmass Creek are avoided.

Impaired Waters (303(d) listed)

Section 303(d) of the CWA requires that States prepare a list of water quality-limited, or impaired, stream segments. The state's Water Quality Control Commission has included the mainstem of Brush Creek from the source to the confluence with the Roaring Fork River in Segment 04_A of the Upper Colorado Roaring Fork Basin, under Assessment Unit (AUID) COUCRF04_A. East Snowmass Creek and Snowmass Creek were assigned AUIDs COUCRF01_A and COUCRF03a_F. In compliance with requirements of the CWA, Section 305(b), the State of Colorado issued its most recent Integrated Water Quality Monitoring and Assessment Report in 2018. The Report classified all three AUIDs under Category 1: attaining water quality standards for all classified uses.[4] These stream segments are classified for Agricultural, Aquatic Life Class 1 Cold water, Recreation E (existing), and Water Supply uses. Numeric water quality standards for physical and biological parameters, and for various metals and inorganic compounds, have been implemented for these segments of the Upper Colorado River Basin.[5]

[4] CDPHE, 2018a.
[5] CDPHE, 2018b.

Snowmass Water & Sanitation District

The Snowmass Water & Sanitation District (SWSD) provides drinking water and treats wastewater for Snowmass Village. It also supplies water needed for snowmaking operations at the Snowmass Ski Area. As required by the Safe Drinking Water Act, the Colorado Department of Public Health and Environment (CDPHE) has completed a source water assessment for the SWSD.[6] The main goal of the assessment is to analyze the potential susceptibility to contamination of public drinking water sources. As part of the assessment, the SWSD source water area was delineated. The source water area defines the region of the watershed or aquifer that contributes untreated water to the public water system's (e.g. the SWSD) source water intake, and defines where potential contamination of this water source could occur.

The SWSD's water supply consists of four surface water sources:[7]

- East Snowmass Creek;
- Snowmass Creek;
- West Fork Brush Creek; and
- East Fork Brush Creek.

The study watersheds subject of this report are tributaries to Brush Creek at a point located downstream from the SWSD's sources of water supply.

3.2.2 Water Yield

Yield of the study watersheds was estimated following the methodologies presented in the WRENSS Procedural Handbook,[8] as updated by Troendle, Nankervis, and Porth,[9] and supplemented by the Colorado Ski Country USA (CSCUSA) Handbook.[10] In summary, the WRENSS Model generates a water balance using seasonal precipitation and vegetation type and density (distributed by watershed aspect) and then computes the amount of water potentially available for runoff. The water balance of the WRENSS Model is coupled with a snowmaking hydrology computation process developed through the CSCUSA study. Together, these calculations produce estimates of water yield typical of subalpine mountain watersheds. The WRENSS Model distributes the calculated annual yield using simulated hydrographs based on data recorded at various streamflow gaging stations. The simulated hydrographs represent the normalized distributions of the annual yield in 6-day intervals throughout the year. It is important to note that the computations do not include routing of runoff water through the watershed to the stream system. Thus, water yield hydrographs do not represent actual streamflow, but rather a time distribution of basin-wide

[6] CDPHE, 2004.
[7] SWSD, 2018.
[8] EPA, 1980.
[9] Troendle et al., 2003.
[10] Colorado Ski Country USA, 1986.

water yield available to the receiving waters. The WRENSS hydrologic model was developed to simulate expected changes in streamflow as the result of silvicultural activities, not streamflow itself.

One of the applications of the WRENSS model is to compare computations of watershed yield and 6-day average peak flows between different watershed conditions. Baseline (or pre-development) conditions in the study watersheds were estimated based upon un-developed watersheds of similar characteristics (e.g. acreage, elevation, aspect) in the vicinity. Vegetation removal associated with construction of roads and housing developments has occurred at the lower elevations of the study watersheds. Ski area development, including ski trail construction and application of snowmaking has also occurred in the Brush Creek Tributaries 1 and 2. Note that for purposes of this analysis, it is assumed that all projects approved in the 2014 Snowmass Ski Trail Enhancements and High Alpine Lift Replacement EA and 2016 Snowmass Multi-Season Recreation Projects EIS have been implemented. **Table 3** compares the acreage of existing forested areas relative to baseline, or pre-development, conditions.

The water yields, expressed in acre-feet (AF), and 6-day peak flows -in cubic feet per second (cfs)- calculated using the WRENSS Model are summarized in **Table 4**, for both baseline and current conditions, and assuming average conditions of precipitation and temperatures. Hydrograph plots that depict the temporal distribution of the computed water yields were also developed for the study watersheds, using the WRENSS Model (see **Figures 1, 2**). These modeled hydrographs reveal the different flow characteristics of baseline and existing conditions in watersheds where tree clearing and snowmaking have occurred. In general, snowmelt hydrographs influenced by vegetation clearing have higher intensity peak flows that occur earlier in the runoff season as compared to pre-development, or baseline conditions. This is a direct consequence of the higher volume and rate of snowmelt due to decreased canopy interception and evapotranspiration, increased solar radiation in cleared areas, and also due to the snowmaking water input.

Table 3

Study Watersheds – Comparison of Baseline and Existing Conditions

Watershed	Drainage Area (acres)	Forested Areas		
		Baseline (acres)	Existing	
			(acres)	(% of Baseline)
Brush Creek Tributary 1	393	349	202	58
Brush Creek Tributary 2	649	633	365	58

Table 4

WRENSS Model Output for Baseline and Existing Conditions

Watershed	Baseline Conditions		Existing Conditions	
	Yield (AF)	6-Day Average Peak Flow (cfs)	Yield (AF)	6-Day Average Peak Flow (cfs)
Brush Creek Tributary 1	112	1.1	283	5.4
Brush Creek Tributary 2	336	2.9	740	8.3

Figure 1

WRENSS Model Output: Brush Creek Tributary 1 Hydrographs

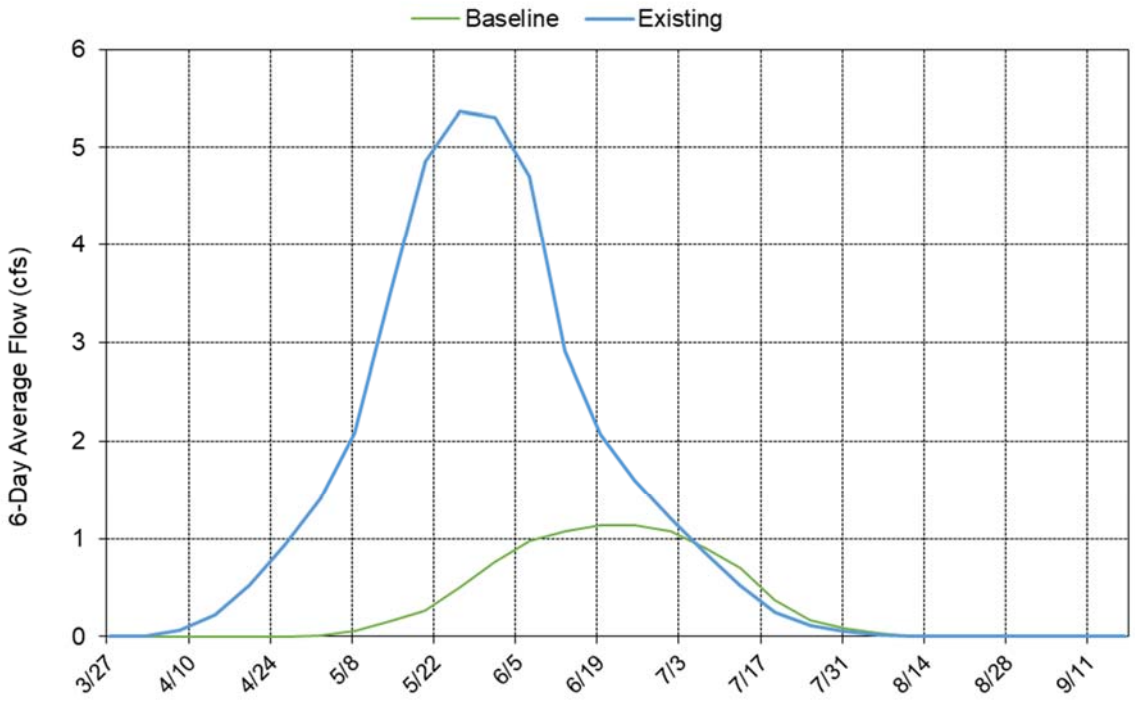
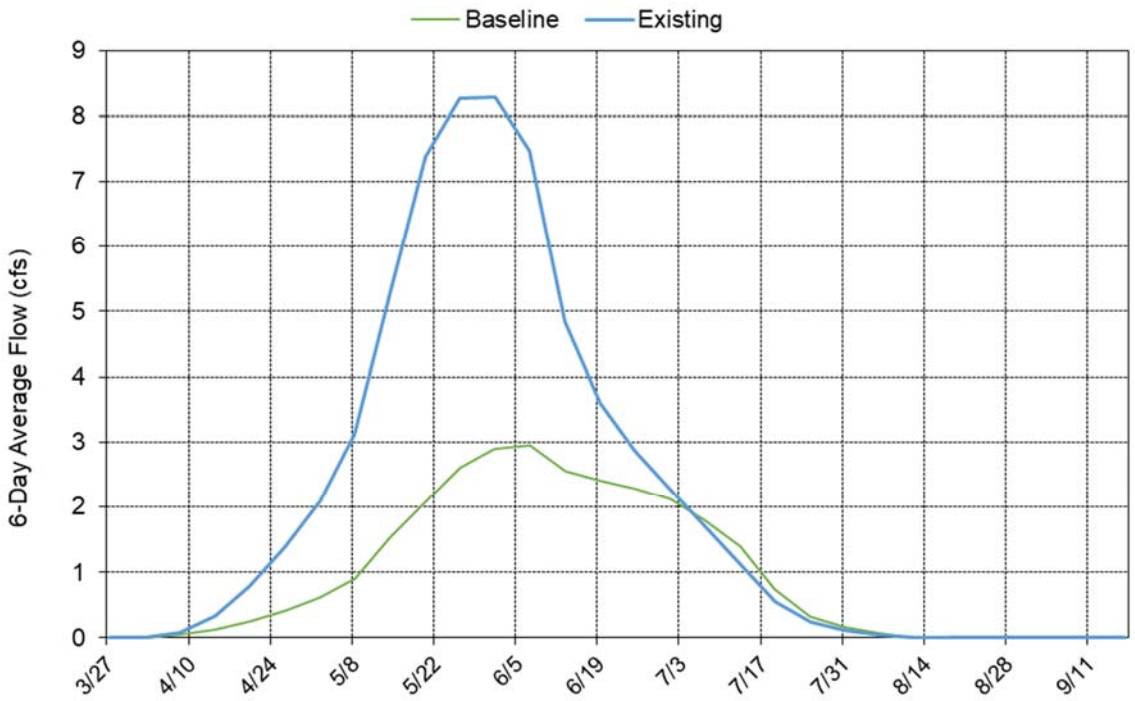


Figure 2

WRENSS Model Output: Brush Creek Tributary 2 Hydrographs



3.2.3 Connected Disturbed Areas

A field investigation completed during the summer of 2016 for the study watersheds provides important information regarding the existing condition of the watershed.[11] Data collected during the 2016 field investigation (supplemented with field observations noted during 2018 site visits), including location and characteristics of graded areas, road-side ditches, and culverts was incorporated into a Geographic Information System (GIS) database in order to estimate the spatial extent of CDAs. In particular, the field investigation focused on the condition of roads and other disturbed areas within the Snowmass Ski Area and in the vicinity of stream channels to determine if such areas route flows directly to the stream system within each watershed. Disturbed areas where clear evidence of direct hydrologic connection to the stream system was observed were classified as CDAs. Generally, mountain roads in Snowmass were found to be in good condition; however, there exist sections of roads that are steep and/or located in close proximity to stream channels. Ruts, rill erosion, and evidence of road drainage flowing directly into the creek were observed in certain areas and thus were classified as connected. Results from this investigation that are relevant to the CDAs analysis are displayed **Figure A-2** and **Tables 5, 6**. In summary, approximately 0.29

[11] Resource Engineering, 2016.

acres of CDA were observed within Brush Creek Tributary 1 and 0.26 acres within Brush Creek Tributary 2. These CDAs are associated with connected roads that are currently in use.

Although not connected to the stream network, a few areas of rill erosion were also observed on ski trails within the study watersheds. These are discussed in the Soils section below.

Table 5
Connected Roads within the Study Watersheds – Existing Conditions

Watershed	Natural Stream Channel Length[a] (feet)	Road Drainage Connected Length[b] (feet)	Percent Increase of Channel Length
Brush Creek Tributary 1	4,264	1,006	24%
Brush Creek Tributary 2	5,855	880	15%

[a] Derived from GIS and field data analysis. Includes ephemeral, intermittent and perennial stream channels.
[b] Within NFS lands.

Table 6
Connected Disturbed Areas within the Study Watersheds – Existing Conditions

Watershed	Connected Disturbed Areas (acres)
Brush Creek Tributary 1	0.29
Brush Creek Tributary 2	0.26

3.2.4 Stream Health

Stream Channel Condition

Channels draining the study watersheds at the higher elevations are ephemeral and intermittent streams that only run for a certain distance before its flowing water infiltrates into the ground or dissipates within forested areas. Included in these are channels that have formed in response to surface runoff originating in clear-cut areas, such as the small intermittent channel that formed downslope from the Showcase and Reidar's ski trails.

Below approximately 9,200 feet of elevation intermittent and perennial streams were observed in the study watersheds. These streams originate below springs and run though forested areas and via culverts across ski area mountain roads. Up-gradient from the mountain access road, the channels appear to have stable banks and be generally good condition. Below the mountain road however, sediment deposits were observed. The streams then leave NFS lands and flow for a short distance before being diverted into pipes that convey them to Brush Creek.

Water Influence Zone

Disturbance of the WIZ has a direct effect on stream health metrics, such as recruitment of large woody

debris and percent of fine sediments on the streambed. The WCPH states the importance of the WIZ in the protection of interacting aquatic, riparian, and upland functions. Furthermore, Management Measure MM-3 includes design criteria requiring that new concentrated-use sites be located outside the WIZ if practicable. **Table 7** compares the extent of the WIZ estimated for pre- development, or baseline, against existing conditions.

Table 7

Impacts to WIZ - Baseline vs Existing Conditions

Watershed	Baseline WIZ (acres)	Existing WIZ (acres)	Existing (% of Baseline)
Brush Creek Tributary 1	11	6	55
Brush Creek Tributary 2	23	14	61

3.2.5 Soils

Ten soil units were identified in the study watersheds. These soils can be grouped into Anvik, Wetopa, Doughspon, Echemoor, Leadville, Scout, Callings, Seitz, Handran, and Eyre families in various associations. Of these, the proposed snowmaking coverage would occur on Leadville and Seitz families, and on Scout-Leadville and Wetopa-Doughspon-Echemoor complexes. These soils can be described as well drained, with low landslide and debris flow potential, and low to moderate erosion hazard.[12] **Table 8** summarizes the general soil characteristics of the soils where snowmaking coverage is proposed.

Table 8

Soil Characteristics in Project Area

Soil Map Unit	Soil Map Unit Description	Landslide Potential	Debris Flow Potential	Erosion Potential
CO8654-338B	Wetopa - Doughspon - Echemoor families complex, 5 to 40% slopes	Low	Low	Moderate-High
CO8654-360C	Leadville family, sandstone substratum, 40 to 65% slopes	Low	Low	Moderate
CO8654-367B	Scout - Leadville families complex, 5 to 40% slopes	Low	Low	Low-Moderate
CO8654-380B	Seitz family, 5 to 40% slopes	Low	Low	Low

[12] USDA Forest Service, 1995.

Bare Ground Analysis

A bare ground assessment completed in 2014 revealed approximately 230 acres in the Snowmass SUP area could benefit from receiving additional rehabilitation by amending those areas that have not recovered with carbonaceous soil amendments. Since that time, Snowmass completed rehabilitation on 8 acres that were identified as priority. An additional 13 to 14 acres of bare ground areas is to be rehabilitated per the requirements of the Snowmass Multi-Season Recreation Projects Record of Decision.[13]

Within the study watersheds subject of this report, soil erosion was observed during the 2018 field review on four areas exhibiting bare ground characteristics. These erosion areas are on the Lunkerville, Lodgepole, Green Cabin, and Adam's Avenue ski trails. See **Figure A-2** and photos in **Attachment B**.

4.0 DIRECT AND INDIRECT ENVIRONMENTAL CONSEQUENCES

4.1 ALTERNATIVE 1 – NO ACTION

Under the No Action Alternative, the existing management practices at Aspen Mountain would continue without changes, additions, or upgrades. The Aspen Skiing Company (ASC) would continue its current summer and winter operations. Removal of vegetation, terrain grading, and/or implementation of additional snowmaking would not result from selection of this alternative. Alternative 1 would have no direct or indirect effects on the watershed resources and the study watersheds would continue to exhibit the condition scores presented in Section 3.

4.2 ALTERNATIVE 2 – PROPOSED ACTION

A detailed description of the proposed projects will be included in Chapter 2 of the EA. Besides construction of two small structures in the Elk Camp Meadows area, the main project proposed under Alternative 2 includes installation of new snowmaking infrastructure to produce man-made snow on 34 acres of existing ski trails (Lodgepole, Lunkerville, and Adam's Avenue). The project would involve construction of approximately 2.1 miles of snowmaking pipelines along these ski trails. To the extent practicable, the alignment of the pipeline was adjusted to avoid wetlands and streams. However, the proposed pipe alignment would cross a short section of an intermittent stream in the Tributary 1 watershed.

4.2.1 Water Quality

The primary potential effects to water quality associated with the proposed activities would be:

(1) Potential effects of increased snowmaking diversions. The source of water supply for snowmaking operations is diversions from East Snowmass Creek into Ziegler Reservoir.

[13] USDA Forest Service, 2017.

(2) Potential increase in sediment loading into receiving streams due to increased amounts surface runoff.

Snowmass Creek Instream Flows

The ASC proposes to expand its Snowmass snowmaking infrastructure to cover approximately 34 acres of terrain that currently do not receive man-made snow. This expansion would require, on average, 25.8 acre-feet (AF) of additional water diversions (34 acres * 0.76 AF per acre = 25.8 AF, see Section 3.2). Under the Proposed Action, snowmaking diversions from Snowmass Creek into Ziegler Reservoir would continue to be subject to instream flow requirements as decreed in Case No. W-2943 and Snowmass would continue to utilize water diverted in-priority into Ziegler Reservoir and in its on-mountain storage ponds. The Proposed Action does not include a proposal to increase the snowmaking system pumping capacity. Instead of increasing the pumping rate, to make artificial snow on the proposed 34 acres of new coverage would require an additional 72 hours of snowmaking operations (distributed over the length of the snowmaking season). In other words, the 25.8 AF of water needed for the proposed snowmaking expansion would involve extending the current length of pumping time by 72 hours per season.

Records maintained by the ASC also indicate that during the snowmaking season (November 1st through December 31st), there are approximately 800 hours when temperatures are sufficient for snowmaking. On average, the Snowmass snowmaking crew complete their snowmaking operations in approximately 570 hours. Therefore, the addition of 72 hours would not require to extend snowmaking operations past December 31st (570 + 72 = 642 total hours, well below the 800 hours typically available for the production of man-made snow during the November through December period).

Because the proposed additional coverage would not result in an increase of the instantaneous demand of snowmaking water, impacts to the Snowmass Creek instream flows are not anticipated to occur under the Proposed Action.

In addition, the CWCB protects its instream flow water rights by enforcing terms and conditions contained in water right decrees, stipulations and agreements. Instream flows are monitored by the CWCB, the Colorado Division of Water Resources (DWR), and the general public to ensure that water rights (including CWCB's instream flows) are being met and administered according to the State's prior appropriation system. Snowmass Creek streamflows below Ziegler Reservoir (i.e., downstream of Snowmass' snowmaking diversions) are continuously monitored by the Snowmass Creek Gaging Station, operated by the DWR. This stream gaging station records streamflow information at 15-minute intervals; real-time streamflow data is available on-line at the DWR's website.[14] If streamflows fall below the instream flow requirements, the CWCB can place an administrative call on Snowmass Creek thereby curtailing upstream junior water rights, including snowmaking diversions into Ziegler Reservoir.

[14] http://www.dwr.state.co.us/Surfacewater/data/detail_graph.aspx?ID=SNOCRECO&MTYPE=DISCHRG

Potential Impacts to Quality of Receiving Waters

As noted above, a higher sediment loading into the un-named Tributaries 1 and 2 could result from an increase surface runoff in the study watersheds. However, the Project Implementation Requirements (PIRs) outlined in the following sections would minimize impacts associated with the Proposed Action. In addition, the proposed improvements to the trail and road drainage infrastructure would contribute to reduce the sediment loading as compared to existing conditions. Therefore, no negative impacts to the water quality of the study watersheds or its receiving waters would result from implementation of the Proposed Action.

Snowmass Water & Sanitation District

The proposed projects would be implemented on areas draining to Brush Creek, at a point located downstream from the SWSD's sources of water supply. Thus, the proposed project area does not overlap or contribute to source water protection area.

4.2.2 Water Yield

Hydrologic computations completed with the WRENSS model show that water yields and 6-day average peak flow rates originating from the study watersheds would increase by approximately 1 to 4 percent relative to existing conditions. These potential changes in water yields and peak flow rates would result from the proposed additional snowmaking coverage. **Tables 9-10** summarize the increases in annual water yield and 6-day average peak flow rates modeled for the Proposed Action under average climatic conditions. **Table 11** displays the existing and proposed snowmaking coverage in the study watersheds.

Table 9

Estimated Changes to Annual Yield – Alternative 2

Watershed	Water Yield (AF)			Change Relative to Existing Yield
	Baseline	Existing	Proposed	
Brush Creek Trib. 1	112	283	294	4%
Brush Creek Trib. 2	336	740	748	1%

Table 10

Estimated Changes to Peak Runoff – Alternative 2

Watershed	6-Day Average Peak Flow (cfs)			Change Relative to Existing Rate
	Baseline	Existing	Proposed	
Brush Creek Trib. 1	1.1	5.4	5.4	0%
Brush Creek Trib. 2	2.9	8.3	8.4	1%

Table 11

Comparison of Existing vs Proposed Snowmaking Coverage

Watershed	Snowmaking Coverage (acres)		
	Existing	Proposed	Cumulative
Tributary #1	26.0	19.8	45.8
Tributary #2	57.5	14.2	71.7

4.2.3 Connected Disturbed Areas

A portion of the proposed snowmaking would be implemented on ski trails that drain towards mountain roads crossed by the study watersheds streams. The additional volume of runoff in the receiving road-side ditches has the potential to increase sediment loading into the channels and extend the acreage of connected areas, especially on the road that crosses the Adam's Avenue ski trail. Improvements to the road drainage infrastructure would be needed to maintain, and likely improve, the study watersheds' condition. Opportunities exist to disconnect nearly all of the current CDAs in the study watersheds by installing and maintaining BMPs for sediment control in the road-side ditches before they discharge in the stream channels. The proposed improvements to drainage conditions are shown in **Figure A-2** and described in more detail in Section 4.2.5 below.

4.2.4 Stream Health

Construction of the proposed snowmaking infrastructure would result in a temporary impact to a small intermittent stream, including its WIZ, located at the upper elevations of the Tributary 1 watershed. The impact would involve approximately 50 linear feet of stream channel, and 0.2 acres of its WIZ. This is the stream that runs near Gwyn's restaurant mentioned in Section 3.1. The temporary impact would result from excavation of a trench across the channel to install the snowmaking pipeline. Following construction, the stream channel and its WIZ would be restored. Details regarding this temporary impact can be found in the Wetland Technical Report completed as part of the EA.[15] No additional impacts to the WIZ in the study watersheds would occur with implementation of the Proposed Action.

4.2.5 Soils

The proposed snowmaking would be implemented on soils with a low landslide and debris flow potential, and with low to moderate-high erosion potential (see **Table 8**). Most of the proposed snowmaking for the Adam's Avenue trail (approximately 2,600 feet) would take place on soils corresponding to map unit 338B, which was identified as having a moderate-high erosion potential. The rest of the proposed snowmaking

[15] Western Bionomics, 2018.

infrastructure would be constructed on soils with a low to moderate erosion potential (map units 360C, 367B, and 380B). The temporary disturbance required to install the snowmaking pipelines and hydrants totals approximately 10.3 acres. This acreage would be restored to original contours (i.e. no additional grading) and revegetated per standard WRNF procedures.

Bare Ground

As described in Section 3.2.5, areas of soil erosion were observed on the Lunkerville, Lodgepole, Green Cabin, and Adam's Avenue ski trails. Except for the erosion on Green Cabin, these areas of erosion are located on ski trails were snowmaking is proposed. The erosion on the Green Cabin, Adam's Avenue and Lunkerville trails occurred on soils classified as having moderate to high erosion potential (Map unit 338B, see **Table 8**). Although soils in the eroded Lodgepole trail were mapped as having a low potential for erosion, the change in slope and corresponding acceleration of surface runoff flows have caused the ski trail surface to erode. In order to maintain or improve conditions in these areas, the proposed snowmaking would have to be implemented following rehabilitation of the eroded soils and construction of ski trail waterbars, adequately spaced, to intercept snowmelt and direct it to the forested areas along the edges of the ski trails. The acreage of the areas where eroded soils would require rehabilitation totals less than 0.1 acre (see **Figure A-2**).

By following soil management requirements and the PIRs listed under Section 4.2.5, no permanent loss of soil organic material is anticipated to occur from implementation of the Proposed Action.

4.2.6 Forest Plan Consistency

The proposed activities would require appropriate measures in order to "maintain or improve" the condition of the study watersheds. The temporary terrain disturbance needed for construction of the proposed projects would require diligent design, installation and maintenance of BMPs for erosion and sediment control. In addition, proposed Project Implementation Requirements (PIR) to be implemented with Alternative 2 projects are outlined below (these are in addition to PIR needed for protection of other resources).

PIR Common to all Projects

- Prior to implementation, submit grading plans for review and authorization by USFS. At a minimum, these documents should meet the basic requirements for stormwater permitting through the State of Colorado Stormwater Management Program.
- Prior to construction, clearly flag wetlands and grading limits.
- Avoid soil disturbing activities during periods of heavy rain or excessively wet soils.
- Drain roads, road ditches, and other disturbed areas to undisturbed soils rather than directly to streams and ephemeral channels. Drainage from disturbed areas should be modified as necessary

using natural topography, rolling dips, waterbars, ditch relief culverts, etc. to achieve this goal.

- Stockpile topsoil so that it may be used for revegetation projects.
- Ground disturbances adjacent to streams/wetlands would occur during baseflow conditions to protect water quality and minimize impacts to wetland soils/vegetation, and with sufficient time to revegetate before the winter season.
- Excavated material should not be stored in the WIZ.
- Construction practices and operations should not introduce soils, debris, or other pollutants into streams, channels, swales, lakes, or wetlands. BMPs adequate for erosion and sediment control should be installed before ground-disturbing activities begin. If natural or biodegradable materials are not used and left on site, all non-natural and non-biodegradable materials should be removed at the end of construction.
- Properly compact fills (MM-11 Design Criteria).
- Where appropriate, revegetate disturbed terrain (including staging areas) immediately after completion of construction using USFS-approved, native seeds. Install temporary BMPs for sediment and erosion control until planted vegetation provides erosion control (MM-11 Design Criteria). Monitor and manage these areas for weeds.
- Revegetation monitoring: ASC shall review with the USFS, the success of project revegetation and site restoration annually for the first five years following construction. Details of the revegetation plan shall be adjusted in response to any deficiencies identified in follow-up monitoring.
- Areas compacted by construction activities may require mechanical subsoiling or scarification to the compacted depth to reduce bulk density and restore porosity.
- Where possible, utilize existing roads and trails to access construction sites.
- To the extent possible, avoid operating heavy equipment on slopes steeper than 30 percent.

PIR for Improvement of Existing Drainage on Mountain Roads in the Study Watersheds

- Improve/construct road ditches and cross drains to limit flow to ditch capacity and prevent erosion and failure (MM-10 Design Criteria). Install road-relief culverts or road waterbars at a spacing adequate for the road slope and ditch characteristics (MM-10 Design Criteria). Adhere to WRNF guidelines for recommended spacing between relief culverts.
- Design, implement, and maintain standard sediment control BMPs (e.g., sediment traps) at the discharge of road-side ditches. Where possible, discharge runoff into well vegetated areas, away from ephemeral and intermittent channels. See Figure A-2.

- Inspect and maintain BMPs a minimum of twice annually: (1) in the spring, as soon as conditions allow; and (2) in the fall season, before snow covers the ground.

PIR for Management of Snowmelt Runoff in the Study Watershed

- Restore approximately 0.1 acres of eroded trail surfaces and revegetate using USFS-approved seeds. See **Figure A-2**.
- Construct ski trail waterbars to intercept and control velocities of surface runoff. Discharge waterbars through adequate BMPs for erosion control in the forested areas adjacent to the ski trail.
- Evaluate construction of waterbars on Adam's Avenue, Lodgepole and Lunkerville ski trails.
- Implement a BMP maintenance program, to inspect, clean and repair or replace BMPs for erosion and sediment control, at least twice annually: as soon as snowmelt conditions allow; and at the end of the summer, before snow covers the ground.
- Following implementation of the proposed snowmaking, inspect ski trails where man-made snow applications occur during the snowmelt season to determine if BMPs are functioning as designed, or if additional BMPs are needed.

Construction and implementation of the Proposed Action following the PIRs outlined above will maintain or improve the overall condition of the study watersheds and, therefore be consistent with the WCPH and Forest Plan standards and will not adversely impact the condition of study watersheds.

5.0 CUMULATIVE EFFECTS

5.1 SCOPE OF THE ANALYSIS

5.1.1 Temporal Bounds

The temporal bounds for this cumulative effects analysis for watershed and soil resources extend from Snowmass' inception as a resort in 1967 through the foreseeable future in which Snowmass can be expected to operate.

5.1.2 Spatial Bounds

The effects on watershed condition that would result from implementation of the Proposed Action would be most evident in the study watersheds. The study watersheds are tributary to Brush Creek, tributary to the Roaring Fork River, where the effects of changes in flow are negligible relative to the hydrology of this larger watershed. The downstream spatial boundary for the cumulative effects analysis is defined at a point immediately downstream from the confluence of Brush Creek and the Roaring Fork River (**Figure A-3**).

5.2 CUMULATIVE EFFECTS ANALYSIS

5.2.1 Alternative 1

The WRNF has completed an assessment of its watersheds following the USFS Watershed Condition Framework Implementation Guide.[16] The assessment rated watersheds at the 12-th HUC level. The 12-th level watershed included in the cumulative effects analysis area is the Brush Creek-Roaring Fork River, Hydrologic Unit Code (HUC) 140100040602 which totals 23,300 acres of drainage area. The Brush Creek-Roaring Fork River watershed was classified as "Functioning Properly". Twelve indicators of watershed condition were examined and rated by the WRNF for the assessment. **Table 12** summarizes the ratings given to each indicator.

Table 12

Summary of Watershed Condition Indicators

Indicator	Brush Creek-Roaring Fork River
Aquatic Biota	Good
Riparian/Wetland Vegetation	Good
Water Quality	Good
Water Quantity	Poor
Aquatic Habitat	Good
Roads and Trails	Poor
Soils	Fair
Fire Regime	Good
Forest Cover	Good
Forest Health	Good
Rangeland Vegetation	Fair
Terrestrial Invasive Species	Good

Under the No Action Alternative, ASC would continue its current summer and winter operations. Removal of vegetation, terrain grading, and/or implementation of additional snowmaking would not result from

[16] USDA Forest Service, 2011a.

selection of this alternative. It is anticipated that the existing activities on private and NFS lands would continue to require management to minimize potential impact to the project area watersheds. Future implementation of projects would require site-specific studies and impacts to water resources would be minimized to the extent practicable.

5.2.2 Alternative 2

Water Quality

Because there are no impacts to water quality anticipated from any of the project components proposed in Alternative 2 (see Section 4.2.1), there would be no cumulative impacts to water quality.

Watershed Condition

The proposed snowmaking coverage and associated increases in watershed yield and peak streamflows discussed in Section 4.2 would not have a measurable effect at the cumulative effects scale. Similarly, the 25.8 AF of new snowmaking diversions would have a negligible impact on the Brush Creek-Roaring Fork River watershed. The additional 25.8 AF of water diversions would occur when water rights are in-priority, and in compliance with the CWCB instream flow water rights, and requirements of the SWSD's permit with the US Army Corps of Engineers related to their water diversions from Snowmass Creek.

Despite direct project effects of the Proposed Action, when considered cumulatively, in addition to past, present, and reasonably foreseeable future actions, implementation of Alternative 2 would maintain stream health and watershed condition through successful implementation of PIRs described in Section 4 of this report. By maintaining the health of the study watersheds, Alternative 2 would not exhibit a negative influence upon watershed conditions in a cumulative context.

6.0 IRREVERSIBLE AND IRRETRIEVABLE COMMITMENTS OF RESOURCES

The Forest Service Handbook 1909.15 provides the following definitions relevant to this analysis:[17]

> Irretrievable: A term that applies to the loss of production, harvest, or use of natural resources. For example, some or all of the timber production from an area is lost irretrievably while an area is serving as a winter sports site. The production lost is irretrievable, but the action is not irreversible. If the use changes, it is possible to resume timber production.
>
> Irreversible: A term that describes the loss of future options. Applies primarily to the effects of use of nonrenewable resources, such as minerals or cultural resources, or to those factors, such as soil productivity that are renewable only over long periods of time.

[17] USDA Forest Service, 2011b.

6.1 ALTERNATIVE 1

The No Action Alternative would result in no additional commitment of resources on NFS lands.

6.2 ALTERNATIVE 2

Additional snowmaking applications would result from implementation of the projects proposed under Alternative 2, as discussed in detail in Section 4 of this report. The additional 25.8 AF of water diversions from Snowmass Creek that would be required for production of man-made snow as proposed under Alternative 2, would result in 6.7 AF of new irretrievable loss of the water resource. However, these losses are not irreversible, since the stream water is a renewable resource and changing the activity (in this case, snowmaking operations) would reduce or stop the loss. Irreversible impacts to stream health and water quality are not expected to occur as a consequence of implementation of Alternative 2 projects. The Proposed Action includes PIRs that would maintain or improve the condition of the study watersheds.

Respectfully Submitted,

RESOURCE ENGINEERING, INC.

Raul Passerini, P.E.
Water Resources Engineer

RP/rp
File: 563-6.14

REFERENCES

- **Chow V.T., Maidment D.R., and Mays L.W., 1988.**
  Chow Van T., Maidment David R., Mays Larry W. Applied Hydrology. McGraw-Hill International Editions, Civil Engineering Series. 1988.

- **Colorado Ski Country USA, 1986.**
  A Final Report on the Colorado Ski Country USA Water Management Research Project. Prepared by Wright Water Engineers, Inc. and Charles F. Leaf. Denver, CO: Colorado Ski Country USA, February 1986.

- **CDPHE, 2018a.**
  State of Colorado, Department of Public Health and Environment. Regulation No. 33 Classifications and Numeric Standards for Upper Colorado River Basin and North Platte River. Effective June 30, 2018.

- **CDPHE, 2018b.**
  State of Colorado, Department of Public Health and Environment. 2018 Integrated Water Quality Monitoring and Assessment Report.

- **Eagleson P.S., 1970.**
  Eagleson Peter S. Dynamic Hydrology. McGraw-Hill Book Company. 1970.

- **EPA, 1980.**
  EPA (Environmental Protection Agency). WRENSS: An Approach to Water Resources Evaluation of Nonpoint Silvicultural Sources (A Procedural Handbook). EPA-600/8-80-012. Washington DC: U.S. Environmental Protection Agency.

- **Overton et al., 1997.**
  Overton, C. Kerry; Wollrab, Sherry P.; Roberts, Bruce C.; Radko, Michael A. 1997. R1/R4 (Northern/Intermountain Regions) fish and fish habitat standard inventory procedures handbook. Gen. Tech. Rep. INT-GTR-346. Ogden, UT: U.S. Department of Agriculture, Forest Service, Intermountain Research Station. 73 p.

- **PRISM Climate Group, 2018.**
  PRISM Climate Group, Oregon State University, http://prism.oregonstate.edu. Accessed August 2018.

- **Resource Engineering, Inc., 2016.**
  Hydrology Report for the Snowmass Multi-Season Recreation Projects Final Environmental Impact Statement. November 2016.

- **Troendle et al., 2003**
  Troendle, C. A., J. M. Nankervis, and L. S. Porth. 2003. The impact of Forest Service Activities on the stream flow regime in the Platte River. Final report submitted to the U. S. Forest Service by MATCOM Corporation. Fort Collins, CO. 50 p. plus Appendices.

- **USDA Forest Service, 1995.**
  USDA Forest Service. 2002a. White River National Forest. Aspen, Dillon, Eagle, Holy Cross, Rifle, and Sopris Ranger Districts. Soil and Ecological Land Unit Survey. Holy Cross Area, Colorado. DRAFT July 1995.

- **USDA Forest Service, 2002.**

USDA Forest Service. 2002a. White River National Forest Land and Resource Management Plan 2002 Revision. White River National Forest, Glenwood Springs. CO.

- **USDA Forest Service, 2005.**
  USDA Forest Service. FSH 2509.25 Watershed Conservation Practices Handbook. Region 2, Lakewood, CO. Draft Final. September 29, 2005.

- **USDA Forest Service, 2011a.**
  USDA Forest Service FS-977. Watershed Condition Framework. A Framework for Assessing and Tracking Changes to Watershed Condition. May 2011.

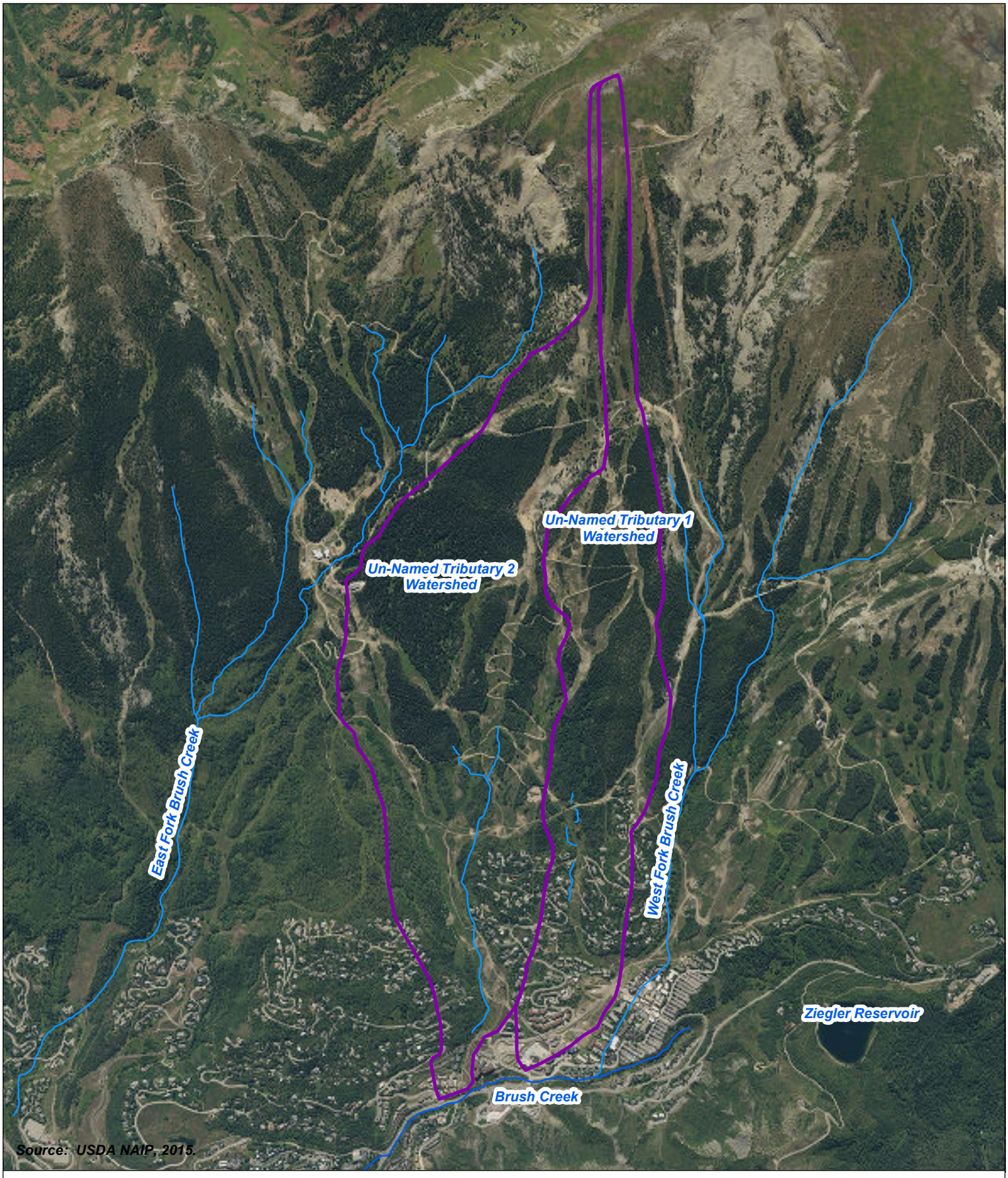
- **USDA Forest Service, 2011b.**
  USDA Forest Service FS 978. Watershed Condition Classification Technical Guide. July 2011.

- **USDA Forest Service, 2017.**
  USDA Forest Service. White River National Forest, Aspen-Sopris Ranger District. Snowmass Multi-Season Recreation Projects. Final Environmental Impact Statement. Record of Decision. June 2017.

- **Western Bionomics, 2018.**
  Snowmass Ski Area. Snowmaking and Elk Camp Meadows Projects. Wetland Technical Report. October 22, 2018.

Attachment A

Report Maps



Snowmass Snowmaking EA
Hydrology Report
Figure A-1. Study Watersheds Map

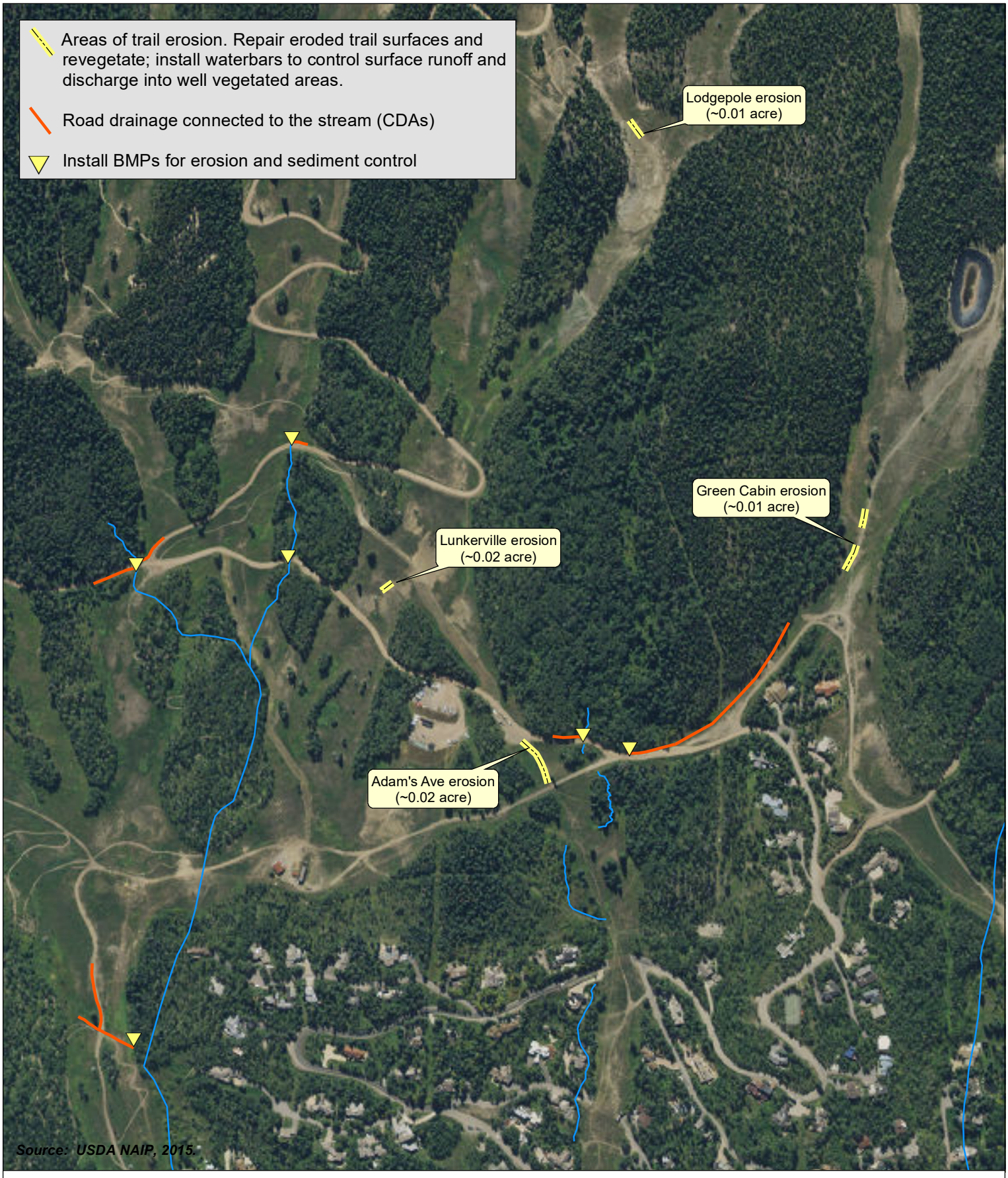
RESOURCE ENGINEERING, INC.
909 Colorado Avenue / Glenwood Springs, CO 81601
Voice: (970) 945-6777 - Web: www.resource-eng.com

1 in = 2,000 ft

0 1,000 2,000 4,000 Feet

N

Date: 2018-11-10
File: 563-6.14
Drawn: RP
Approved: AS



Snowmass Snowmaking EA
Hydrology Report
Figure A-2. CDAs and Trail Erosion Map

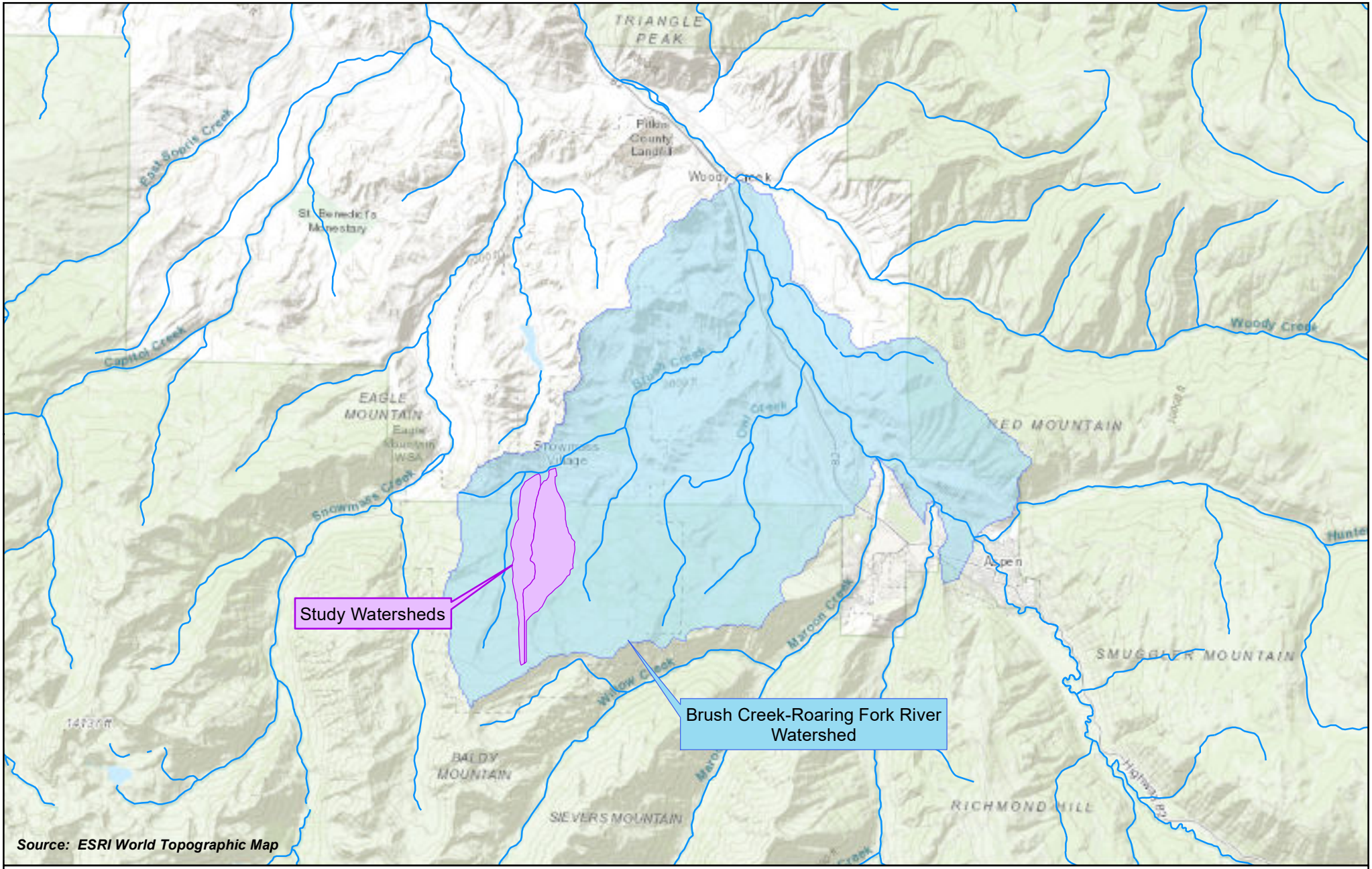
RESOURCE ENGINEERING, INC.
909 Colorado Avenue / Glenwood Springs, CO 81601
Voice: (970) 945-6777 - Web: www.resource-eng.com

1 in = 500 ft

0 250 500 1,000 Feet

N

Date: 2018-12-07
File: 563-6.14
Drawn: RP
Approved: AS



Snowmass Snowmaking EA
Hydrology Report
Figure A-3. Cumulative Effects Watershed Map

RESOURCE ENGINEERING, INC.
909 Colorado Avenue / Glenwood Springs, CO 81601
Voice: (970) 945-6777 - Web: www.resource-eng.com

1 in = 2 miles

0 1 2 4 Miles

N

Date: 2018-12-10
File: 563-6.14
Drawn: RP
Approved: AS

Attachment B

Photographs

Photo 1
Rill erosion on the lower elevations of the Lunkerville ski trail

Photo 2
Same area of erosion on the Lunkerville ski trail; note Alpine Springs lift tower #5

Photo 3
Rill erosion on an un-vegetated area of the Adam's Avenue ski trail, just downslope from the Hiker and Horseback Parking area.

Photo 4
Soil erosion due to runoff originating from a service road on the Green Cabin trail